

Structure for Mounting Multifunctional Vibrating Actuator on Circuit Board

Field of Technology of Invention

[0001] This invention concerns a structure for mounting on the circuit board a multifunctional vibrating actuator to be installed in portable terminal equipment such as portable telephones.

Prior Technology

[0002] Devices for notification of incoming calls is mounted in portable terminal equipment such as portable telephones; among these devices are multifunctional vibrating actuators that have been devised and implemented to inform users of incoming calls by means of an audible melody or buzzer or a bodily sensible vibration, and also function as a receiver speaker.

[0003] Figure 20 shows a typical structure of a multifunctional vibrating actuator as described above (see, for example, Patent Document 1).

[0004] Patent Document 1: JPO Pre-Grant Patent Publication 3363792 (pp. 3 to 6, figure 1)

[0005] As shown in figure 20, the multifunctional vibrating actuator 100 has a flat casing with a cylindrical housing 2 that is open at both ends, with a plate-shaped cover 101 attached to the upper opening of the housing 2 and a plate-shaped bracket 3 attached to the lower opening of the housing 2. Within this casing there is a diaphragm 4 that produces sound waves by being vibrated at a resonant frequency in the audible range (such as 2.5 kHz) and a magnetic circuit 5 that vibrates the casing by being vibrated at a resonant frequency lower than the resonant frequency of the diaphragm 4 (such as 130 Hz). Further, there is a terminal seat 9 on the housing 2 to which are attached a pair of terminals 102, 103 for input to the voice coil 12 of a driver signal that drives the diaphragm 4 and/or the magnetic circuit 5.

[0006] The pair of terminals 102, 103 has left/right symmetry and the two have basically the same structure; therefore only the terminal 102 is explained here. As shown in figure 21, the terminal 102 comprises a strip-shaped terminal body 102a and a contact 102b that is formed by bending the strip at a right angle at the lower end of the terminal body 102a. A connector 102c is formed as a notch at the upper end of the terminal body 102a. Further, two wedges 102d, 102e with a height of about 0.1 mm project from the edges of the terminal body 102a. By this means, when the terminals 102, 103 are inserted into the terminal seat 9, the wedging action of the wedges 102d, 103e holds them firmly in the terminal seat 9.

[0007] The magnetic circuit 5 comprises a suspension 13 formed so that it can deform flexibly in the up and down direction of figure 20, a magnet 6, and a pole piece 7 and a yoke 8 that sandwich the magnet 6. The magnetic circuit 5 is fastened to the inner periphery of the suspension 13, and the outer periphery of the suspension 13 is

attached by means of sandwiching between the housing 2 and the bracket 3. In this way, the magnetic circuit 5 is able to vibrate up and down relative to the housing 2.

[0008] The diaphragm 4, on the other hand, has a voice coil 12 attached to it, and its outer periphery is sandwiched between the housing 2 and the cover 101. A portion of the voice coil 12 is drawn outside the housing 2 and attached to the connectors 102c, 103c of the terminals 102, 103 as shown in figure 22, thus electrically connecting the terminals 102, 103 and the voice coil 12. In this way, the diaphragm 4 is able to vibrate up and down relative to the housing 2. The voice coil 12 is located within the electrical gap G of the magnetic circuit 5. By this means, when a driver signal is impressed on the voice coil 12, a magnetic attraction or repulsion operates between the magnetic circuit 5 and the diaphragm 4. Accordingly, by changing the frequency of the driver signal impressed on the voice coil 12, it is possible to drive vibration of the magnetic circuit 5 and/or the diaphragm 4.

[0009] In order to make the electrical connection between the terminals mentioned above and the circuit board that is installed in the portable terminal equipment, this sort of multifunctional vibrating actuator has been both mounted on the surface of the circuit board and held in place by the case of the portable terminal equipment.

[0010] In recent years, the multifunctional vibrating actuator has had to be fixed to the surface of the circuit board by means of solder reflow. That is because the components other than the multifunctional vibrating actuator—the ICs and LSIs—are mounted on the surface of the circuit board by means of solder reflow, and work efficiency is improved if the multifunctional vibrating actuator is compatible with solder reflow fixing and can be mounted to the circuit board in the same process as the other components.

[0011] The mounting of the multifunctional vibrating actuator 100 to the surface of the circuit board by means of solder reflow fixing is explained next with reference to figures 23 through 25. As shown in figure 23, a land 104b for solder reflow fixing of the bracket 3 is formed in advance on the surface of the circuit board 14, and electrodes 104a, 104a [sic] are formed there for the solder reflow fixing of the contacts 102b, 103b of the terminals 102, 103. Then, at the time of solder reflow mounting and fixing, a cream solder (not illustrated) is applied to the land 104b and the electrodes 104a, 105a.

[0012] Next, as shown in figures 24 and 25, the multifunctional vibrating actuator 100 is positioned on the surface of the circuit board 14. It is aligned to position the bracket 3 on the land 104b and the contacts 102b, 103b, on the electrodes 104a, 105a. Then the circuit board 14 with the multifunctional vibrating actuator 100 is inserted in a reflow tank and heated to melt the solder. After heating, the circuit board 14 is removed from the reflow tank, the solder solidifies, and the multifunctional vibrating actuator 100 is fixed to the surface of the circuit board 14.

Disclosure of the Invention

Problems to be Resolved by the Invention

[0013] However, in the conventional constitution, the multifunctional vibrating actuator 100 is positioned on the circuit board 14, and then the multifunctional vibrating actuator 100, together with the circuit board 14, is placed in the reflow tank where the solder melts and solidifies. Accordingly, the components that make up the multifunctional vibrating actuator 100 are unavoidable exposed to the high temperatures of the reflow tank. Because the diaphragm 4 is made of an industrial plastic such as PET, there is a problem of deformation due to the high temperature, which has an adverse effect on the acoustic characteristics.

[0014] Moreover, a rare earth magnet is frequently used as the magnet in the magnetic circuit of the multifunctional vibrating actuator, and there is the problem of a loss of magnetism because of the high temperature of the reflow tank and deterioration of magnetic characteristics.

[0015] Further, in the conventional constitution, a portion of the voice coil 12 is directly connected electrically to the terminals 102, 103, and so the heat of the reflow tank is conducted through the electrodes 104a, 105a and the terminals 102, 103 to the voice coil 12, which sometimes gives rise to abnormal short circuits due to breakdown of the insulation layer of the lead wires that form the voice coil.

[0016] The purpose of this invention is to resolve the problems described above by making it possible to mount and fix the multifunctional vibrating actuator to the surface of the circuit board by solder reflow; the multifunctional vibrating actuator is mounted and fixed on the surface of the circuit board by first mounting and fixing the bracket to the surface of the circuit board by solder reflow, and then attaching the multifunctional vibrating actuator to the bracket.

[0017] Because the solder melts during the solder reflow, there is the further problem that the surface tension of the molten solder causes the mounted components to float up, and the precision of component positioning relative to the surface of the circuit board is reduced. This invention has the purpose of resolving the problems that occur during the actual mounting and fixing of the multifunctional vibrating actuator on the surface of the circuit board by solder reflow, and thus providing a solder reflow method of mounting on the circuit board that allows high precision in the positioning of the multifunctional vibrating actuator relative to the surface of the circuit board.

Means to Resolve the Problems

[0018] The invention described in claim 1 of this invention provides a structure for mounting a multifunctional vibrating actuator on a circuit board, the multifunctional vibrating actuator having a diaphragm, a magnetic circuit that is positioned facing the diaphragm and that forms a magnetic path, a suspension that supports the magnetic circuit, a housing that supports the diaphragm and the suspension, and a means of driving that produces magnetic drive that operates between the diaphragm and the magnetic circuit, and having terminals that are attached to the housing and that are electrically connected to the means of driving, in which multifunctional vibrating actuator a bracket is fixed to the surface of the circuit board by means of solder reflow and the housing is held in place by the bracket, such that the multifunctional vibrating actuator is mounted on the surface of the circuit board with the terminals electrically connected to the circuit board.

[0019] The invention described in claim 2 of this invention provides a structure for mounting a multifunctional vibrating actuator on a circuit board, in which the mounting position of the multifunctional vibrating actuator relative to the circuit board is set on the surface near one end of the circuit board, and in which there is a projection on the surface of the bracket that faces the circuit board, the bracket being fixed by solder reflow to the surface of the circuit board while it is held in place on the surface of the circuit board by the projection.

[0020] The invention described in claim 3 of this invention provides a structure for mounting a multifunctional vibrating actuator on a circuit board, in which the surface of the bracket that faces the circuit board has two or more convex contacts that contact solder applied to the surface of the circuit board and are fixed by solder reflow.

[0021] The invention described in claim 4 of this invention provides a structure for mounting a multifunctional vibrating actuator on a circuit board, in which the multiple contacts are set at the edge of the bracket.

[0022] The invention described in claim 5 of this invention provides a structure for mounting a multifunctional vibrating actuator on a circuit board, in which flat electrodes formed on the surface of the circuit board are formed with different ratios of length measurement to width measurement, and the positive electrode and the negative electrode have positions that are the same in the length direction.

[0023] The invention described in claim 6 of this invention provides a structure for mounting a multifunctional vibrating actuator on a circuit board, in which flat electrodes formed on the surface of the circuit board are formed with different ratios of length measurement to width measurement, and the positive electrode and the negative electrode have positions that differ in the length direction.

[0024] The invention described in claim 7 of this invention provides a structure for mounting a multifunctional vibrating actuator on a circuit board, in which the bracket is formed in a dish shape, with a bottom part and a rim that rises from the edge of the bottom part, the end of the housing of the multifunctional vibrating actuator being fitted to the rim to attach the bracket to the housing, there being a tab on the end of the housing that fits with the rim and multiple cut-outs in the rim that fit with the tab, the cut-outs being formed as a unit by cutting lower than the height of the cut-outs.

[0025] The invention described in claim 8 of this invention provides a structure for mounting a multifunctional vibrating actuator on a circuit board, in which the flat surface of the bracket is formed with an unequal length/width ratio, and there are on the surface of the bracket rim on the longer axis of the length/width ratio two or more convex contacts that contact the solder applied to the surface of the circuit board and that are fixed by solder reflow.

[0026] The invention described in claim 9 of this invention provides portable terminal equipment in which a multifunctional vibrating actuator is mounted using any of the mounting structures described in claims 1 through 8 to mount the multifunctional vibrating actuator on the circuit board.

Effect of the Invention

[0027] As explained above, by using the invention described in claim 1 of this invention, the bracket is first fixed to the surface of the circuit board by solder reflow. After the heat has radiated from the circuit board and the bracket, the multifunctional vibrating actuator that is completely assembled except for the bracket is fitted and fixed in place to mount it on the bracket. In this way, the multifunctional vibrating actuator can be mounted on the circuit board with the components of the multifunctional vibrating actuator that have little resistance to the high temperatures that accompany heating in the reflow tank during solder reflow fixing (the voice coil, diaphragm, and magnet) not being exposed to the high temperatures of the reflow tank.

[0028] Moreover, by using the invention described in claim 2 of this invention, a projection is formed as a part of the bottom surface of the bracket that contacts the circuit board, and so it is possible to fix the bracket to the surface of the circuit board by solder reflow with the projection held in place at the end of the circuit board. Accordingly, in addition to the effect of claim 1, even if surface tension is produced between the bottom of the bracket and the surface of the circuit board when the solder melts, the projection is held in place at the end of the circuit board and the bracket is prevented from floating up from the surface of the circuit board. Therefore, it is possible to fix the bracket to the surface of the circuit board by solder reflow fixing while assuring accurate positioning of the bracket on the surface of the circuit board.

[0029] Because the bracket is fixed by solder reflow with accurate positioning assured, the multifunctional vibrating actuator that is fitted and fixed to the bracket can be mounted on the surface of the circuit board with accurate positioning.

[0030] Moreover, by using the invention described in claim 3 of this invention, there are on the surface of the bracket that faces the circuit board two or more convex contacts that contact the solder applied to the circuit board and are fixed by solder reflow. Therefore, in addition to the effects described above, it is possible to limit the portion affected by surface tension to the small number of contacts. Accordingly, the bracket can be fixed in place with accurate positioning on the circuit board using an accurate self-alignment effect.

[0031] Moreover, in addition to the effects described above, by using the invention described in claim 4 of this invention the multiple contacts are located on the edge of the bracket, and so the space between the contact portions affected by surface tension is as large as possible, enabling an accurate self-alignment effect.

[0032] Moreover, by the using the inventions described in claims 5 and 6, the flat electrodes formed on the surface of the circuit board are formed with different ratios of length measurement to width measurement, and the positive electrode and the negative electrode have positions that are the same in the length direction; this makes it possible to have a certain degree of width in the width measurement of the electrodes. In addition to the effects described above, therefore, even if the overall position of the multifunctional vibrating actuator is not correct because the bracket is floated up by the molten solder during solder reflow and the contact position of the terminals is outside the defined position, it is possible to make up for that when the

actuator is fitted and fixed to the bracket by means of the expanded dimensions of the electrodes in the width direction. Accordingly, electrical contact between the multifunctional vibrating actuator and the circuit board can be assured by always securing contact between the terminal contact points and the electrodes.

[0033] Therefore, this is very suitable as a structure for solder reflow fixing of the multifunctional vibrating actuator.

[0034] Moreover, by using the invention described in claim 7, there are multiple cut-outs in the rim of the bracket that fit with the tab on the end of the housing, the cut-outs being formed as a unit by cutting lower than the height of the cut-outs. In addition to the effects described above, even if the position of the cut-outs relative to the surface of the circuit board changes because the bracket is floated by the self-alignment effect, there are multiple cut-outs at a distance that corresponds to the amount that the bracket floats, and so one of the multiple cut-outs will always be located at a given position relative to the circuit board. Consequently, it is possible to fit and fix the multifunctional vibrating actuator to the bracket while having it always in a given position relative to the surface of the circuit board, and so electrical contact between the multifunctional vibrating actuator and the circuit board can always be assured by securing contact between the contact points of the terminals and the electrodes.

[0035] Moreover, by using the invention described in claim 8, the flat surface of the bracket is formed with a different length/width ratio and there are at least two convex contacts at the edge of the bracket on the long axis of the length/width ratio, which contact the solder applied to the surface of the circuit board and are fixed to it by solder reflow, and so it is possible to increase the space between the contacts. Accordingly, in addition to the effects described above, it is possible to achieve a more accurate self-alignment effect, and so the bracket can be fixed to the surface of the circuit board by solder reflow with more accurate positioning relative to the circuit board. Therefore, it is possible to further improve the precision of the positioning, relative to the circuit board, of the multifunctional vibrating actuator that is fitted and fixed to the bracket.

[0036] Moreover, by using the invention described in claim 9, it is possible to mount the multifunctional vibrating actuator in portable terminal equipment by means of the effects of the inventions described in claims 1 through 14 [sic].

Embodiments of the Invention

[0037] First Embodiment

The first embodiment of the structure for mounting a multifunctional vibrating actuator on a circuit board (referred to below, as necessary, simply as the structure for mounting on a circuit board) of this invention is explained below with reference to figures 1 through 6. Figure 1 is an oblique view showing an external view of the multifunctional vibrating actuator involved in the structure for mounting on a circuit board of this embodiment. Figure 2 is a cross section, taken at the broken line A—A of figure 1. Figure 3 is an oblique view of the bracket that is a part of the multifunctional vibrating actuator. Figure 4 is an oblique view of the bracket in

figures 1 through 3 when it is fixed by solder reflow to the surface of the circuit board. Figure 5 is a side view of a portion of figure 4. Figures 6 and 7 are side views of the multifunctional vibrating actuator being placed in the bracket fixed to the circuit board. Now, the components within the structure of the multifunctional vibrating actuator that have the same functions as those in the conventional example described above also have the same labels in the drawings, and duplicative explanations are omitted or simplified.

[0038] As shown in figure 2, the multifunctional vibrating actuator 1 that is mounted by the structure for mounting on a circuit board of this invention has, within a housing 2, a magnetic circuit 5 that produces a bodily sensible vibration and a diaphragm 4 that produces sounds. The housing 2 is cylindrical and is open at both ends; in the upper opening is a step 2a. The diaphragm 4, which is attached to a voice coil 12 that is the driving means that produces the magnetic impulse that operates between it and the magnetic circuit 5, is fixed to this step 2a and supported by the housing 2. The voice coil 12 that is fixed to the central portion of the diaphragm 4 is inserted in the magnetic gap G of the magnetic circuit 5 when the diaphragm 4 is fixed to the step 2a, and a portion of it [the voice coil 12] is drawn outside the housing 2. A terminal seat 9 is formed as a part of the housing 2 and extends out in a radial direction from the outer periphery of the housing 2; a pair of terminals 15, 16 is attached to the terminal seat 9. Moreover, the portion of the voice coil that is drawn outside the housing 2 is connected to the terminals 15, 16 by a means of fixing such as soldering. In this way, the terminals and the voice coil are electrically connected.

[0039] The magnetic circuit 5 comprises a magnet 6 that is magnetized in the up and down direction of figure 2, a pole piece 7, and a yoke 8, so as to form a magnetic path through the magnetic gap G; it is flexibly supported with respect to the housing 2 by a suspension 1. The yoke 8 is formed in a dish shape with an interior depression, the magnet 6 being accommodated within the depression with the end face 6a of the magnet being fixed to the bottom surface 8a of the yoke 8. The disk-shaped pole piece 7 is fixed to the other end face 6b of the magnet 6. The yoke 8, the magnet 6, and the pole piece 7 are all circular when viewed from the top (the direction of arrow a [sic]), and all three parts are assembled on the same center and fixed. The magnet 6 is a rare earth magnet that has been powdered, sintered and solidified, then magnetized.

[0040] The open end of the housing opposite the open end to which the diaphragm 4 is fixed is slightly smaller in its outside diameter, and a tab 2c is formed on the slightly smaller outer wall 2b. The bracket 3 is fitted and fixed to this smaller open end. The bracket 3 and the housing 2 make up the casing of the multifunctional vibrating actuator 1. As shown in figures 2 and 3, the bracket 3 is dish-shaped, with a flat bottom 3a and a rim 3b that rises vertically from the edge of the bottom 3a. The rim 3b has a cut-out 3c to fit with the tab 2c on the housing 2. The cut-out 3c is formed in the same shape as the tab 2c, and its size is slightly larger than that of the tab 2c.

[0041] Next, the structure for mounting on a circuit board is explained with reference to figures 3 through 7. First, before it is fitted to the open end of the housing 2, the bracket 3 that is a part of the casing of the multifunctional vibrating actuator 1 is fixed by solder reflow to the surface of the circuit board 14. A cream solder 17 is applied by patterning printing on the surface of the circuit board 14 that is to be placed inside the

portable terminal equipment case. The bracket 3 is set in place on the surface of the circuit board 14 with the face of the bracket bottom 3a in contact with a portion of the applied solder 17.

[0042] With the bracket 3 in place, the circuit board 14 is inserted into a reflow tank (not illustrated). The solder 17 is melted by heating in the reflow tank. After heating, the circuit board 14 is removed from the reflow tank, and the melted solder solidifies as the heat dissipates. In this way, the bracket positioned on the circuit board 14 is fixed to the circuit board 14 by solder reflow.

[0043] The bracket 3 can be made of stainless steel, a polymer, or other material. If the bracket 3 is made of a material with no adhesion to the solder 17, just the face that contacts the solder 17 can be made of metal.

[0044] After the heat has dissipated from the circuit board 14 and the bracket 3, the multifunctional vibrating actuator 1 with all parts assembled other than the bracket 3 is fitted and fixed in place in the bracket 3, as shown in figures 6 and 7. The fitting, as described above, is done by fitting the tab 2c of the housing 2 and the cut-out 3c of the bracket 3. The bracket 3 will have been fixed to the surface of the circuit board with a position relative to the electrodes 18, 19 that are formed on the circuit board 14 such that, when the housing 2 is fitted to the bracket 3, the terminals 15, 16 will contact and be electrically connected to the electrodes 18, 19.

[0045] In this way, using the structure for mounting on a circuit board of this embodiment makes it possible for a multifunctional vibrating actuator to be mounted on the surface of a circuit board by solder reflow without exposing the components of the multifunctional vibrating actuator that have poor heat resistance to the high temperatures that accompany heating in a reflow tank during solder reflow fixing (the voice coil, the diaphragm, and the magnet) to the high temperatures of the reflow tank.

[0046] Second Embodiment

Next, the second embodiment of this invention for a structure for mounting on a circuit board is explained below with reference to figures 8 through 10. Now, the components that have the same functions as those in the first embodiment described above also have the same labels in the drawings, and duplicative explanations are omitted or simplified. Figure 8 is an oblique conceptual view showing the relative positions of the multifunctional vibrating actuator and the circuit board within the portable terminal equipment. Figure 9 is an oblique view showing an external view of the multifunctional vibrating actuator of the second embodiment. Figure 10 is an oblique view showing the multifunctional vibrating actuator of figure 9 mounted on the circuit board, and figure 11 is a side view of the bracket.

[0047] The point on which the second embodiment differs from the first embodiment is that a projection 3d is formed as a unit with the bottom surface 3a' of the bracket 3 that is in contact with the circuit board 14. As shown in figure 8, the multifunctional vibrating actuator 1 acts as the speaker that conveys to the user the sound received from the other end of the communication, and so when placed in the portable terminal equipment 21 it is located at a point corresponding to the user's ear. In most cases,

therefore, it is located inside one end of the case of the portable terminal equipment 21.

[0048] For mounting at the end of the case of the portable terminal equipment 21, the position of the multifunctional vibrating actuator 1 should also be placed toward one end of the circuit board 14. Therefore, in consideration of mounting at the end of the circuit board 14, a projection 3d is formed on the bottom surface 3a' of the bracket 3 that is in contact with the circuit board 14, and with the projection 3d held in place at the end 14a of the circuit board 14, the bracket 3 is fixed to the surface of the circuit board 14 as explained in the first embodiment; after the bracket 3 is fixed, the multifunctional vibrating actuator 1 is placed in the bracket 3.

[0049] The projection 3d can be formed by cutting the bottom face 3a and making it project, or by forming it as a part separate from the bracket 3 and bonding it to the bottom face 3a'. The height H of the projection 3d is preferably the same as the height of the end of the circuit board 14, or in other words, the thickness of the circuit board 14.

[0050] By means of the structure described above, even if surface tension is produced between the bottom face 3a' of the bracket 3 and the surface of the circuit board 14 when the solder melts, the projection 3d will be maintained in place at the end 3d of the circuit board 3 [sic], and so the bracket 3 will be prevented from floating up from the surface of the circuit board 14. Thus the bracket 3 can be fixed to the surface of the circuit board 14 by solder reflow fixing with the bracket 3 accurately positioned on the circuit board 14.

[0051] The bracket 3 is fixed by solder reflow with accurate positioning, and so the multifunctional vibrating actuator 1 that is ultimately fitted and fixed in the bracket can be mounted on the circuit board 14 with accuracy and precision.

[0052] Third Embodiment

Next, the third embodiment of this invention for a structure for mounting on a circuit board is explained with reference to figures 12 and 13. Figure 12 is a bottom plane view of the bracket in the third embodiment of the structure for mounting on a circuit board, and figure 13 is a plane view showing the bracket of figure 12 when fixed by solder reflow to the circuit board. Now, the components that have the same functions as those in the embodiments described above also have the same labels in the drawings, and duplicative explanations are omitted or simplified.

[0053] The point on which the third embodiment differs from the embodiments described above is that there are at least two convex contact points on the bottom face 3a' of the bracket 3; these contact the solder applied to the surface of the circuit board 14 and are fixed by solder reflow.

[0054] As described above, when the solder melts during the solder reflow fixing of the bracket 3, surface tension is produced in the molten solder between the bottom face 3a' of the bracket 3 and the surface of the circuit board 14, and the bracket 3 floats up. Using this embodiment, however, convex contacts 3e are placed on the bottom face 3a', by which means contact with molten solder across the full bottom

face 3a' is prevented. Therefore, only the contacts 3e touch the molten solder, and the portion affected by surface tension can be limited to the contacts 3e. By limiting the portion affected by surface tension to a few contacts, it becomes possible to achieve a self-alignment effect in which the bracket 3 is moved to the designated position on the surface of the circuit board and the bracket 3 is accurately positioned on the circuit board.

[0055] In this way, using this embodiment limits the portion affected by surface tension to a few contacts and makes it possible to accurately position the bracket on the surface of the circuit board by means of the self-alignment effect.

[0056] In order to assure the self-alignment effect, moreover, it is effective to increase as much as possible the space between the few contacts that are affected by surface tension. Therefore, it is most suitable to place the contacts 3e on the edge of the bottom face 3a' of the bracket 3, as shown in figure 14, and to locate the contacts 3e on opposite edges with symmetry around the center point of the bottom face 3a'. By locating the contacts 3e in this way, it is possible to maximize the space between the contact points 3e and achieve a more accurate self-alignment effect.

[0057] Fourth Embodiment

Next, the fourth embodiment of this invention for a structure for mounting on a circuit board is explained with reference to figures 15 and 16. Figure 15 is a plane view showing the tops of the electrodes of the fourth embodiment of the structure for mounting on a circuit board, and figure 16 is a plane view of a modification of the electrodes in figure 15. Now, the components that have the same functions as those in the embodiments described above also have the same labels in the drawings, and duplicative explanations are omitted or simplified.

[0058] The point on which the fourth embodiment differs from the embodiments described above is that the shape, when seen from above (hereafter a "plane view," as necessary), of the electrodes 19', 19' that are set on the surface of the circuit board is one with measurements that are different, as shown in figure 15, in the length direction (the direction of the arrow L in the figure) and the width direction (the direction of the arrow W in the figure).

[0059] Moreover, the two electrodes 18', 19', positive and negative, are formed to have the same position in the length direction in a plane view [i.e., the same distance from the edge of the circuit board]; they are insulated by the space between the electrodes.

[0060] Because multiple contacts 3e are formed on the bottom face of the bracket 3, as described above, the bracket 3 is floated in the direction of arrow b by the self-alignment effect when it is fixed to the surface of the circuit board 14 by solder reflow. Consequently, the electrodes are formed in a roughly rectangular shape with different measurements in the length and width directions, and run along the direction in which the bracket 3 floats. Since the float direction of the bracket 3 is a rough arc, as shown by the direction of arrow b in the figure, the electrodes 18', 19' are rectangular and generally arc-shaped.

[0061] Forming the electrodes 18', 19' in this way makes it possible to give the electrodes 18', 19' a degree of width in their measurement in the direction of the width. Accordingly, when the multifunctional vibrating actuator 1 is fitted and fixed to the bracket 3, even if floating by the bracket 3 moves the general location of the multifunctional vibrating actuator 1 away from its designated position and the contact points of the terminals 15, 16 are not in their designated positions, the wider measurements of the electrodes 18', 19' in the direction of width will make up for that positioning error. Therefore, even if the bracket 3 is floated by the solder reflow fixing, contact between the contact points of the terminals 15, 16 and the electrodes 18', 19' is always assured, and so it is possible to have a certain electrical connection between the multifunctional vibrating actuator 1 and the circuit board 14.

[0062] Therefore, the plane view shape of the electrodes 18', 19' of this embodiment is optimum for a structure for fixing the multifunctional vibrating actuator by solder reflow.

[0063] Now, this embodiment can be modified in various ways on the basis of technical considerations. For example, if the positions of the terminal contact points of the multifunctional vibrating actuator are laid out in the length direction, then as shown in figure 16, the positive and negative electrodes 18', 19' can be formed in different positions in the length direction. Forming them in this way can make the insulation between the electrodes 18', 19' more certain.

[0064] Fifth Embodiment

Next, the fifth embodiment of this invention for a structure for mounting on a circuit board is explained with reference to figure 17. Figure 17 is an oblique view of the bracket of the fifth embodiment and a portion of the housing of the multifunctional vibrating actuator to be fitted and fixed in the bracket. Now, the components that have the same functions as those in the embodiments described above also have the same labels in the drawings, and duplicative explanations are omitted or simplified.

[0065] The point on which the fifth embodiment differs from the embodiments described above is that the rim 3b of the bracket 3 has multiple cut-outs 3c, 3c to fit with a single tab 2c. The cut-outs 3c, 3c are formed as a unit by a cut 3f that has a height lower than that of the cut-outs 3c, 3c.

[0066] As explained in regard to the first embodiment, the opening at one end of the housing 2 of the multifunctional vibrating actuator 1 and the bracket 3, which is fixed by solder reflow to the surface of the circuit board 14, are firmly fixed together by fitting the tab 3c [sic] into a cut-out 3c. However, because the self-alignment effect causes the bracket 3 to float in the direction of the arrow b of figure 17 during solder reflow, the position of the cut-out 3c relative to the surface of the circuit board 14 cannot be determined uniformly. Accordingly, the positions of the contact points of the terminals 15, 16 (not illustrated in figure 17) of the multifunctional vibrating actuator 1 that is fitted and fixed to the bracket 3 similarly cannot be determined uniformly. There is, therefore, a risk that the electrodes 18, 19 and the contact points of the terminals 15, 16 will not line up when the multifunctional vibrating actuator 1 is fitted and fixed to the bracket 3.

[0067] This embodiment, however, has multiple cut-outs 3c, 3c spaced at an interval that corresponds to the amount of bracket 3 float (the measurement of arrow b) caused by the self-alignment effect, and so the float will always position one of the cut-outs 3c, 3c in a given location relative to the surface of the circuit board 14. Accordingly, it will be possible to fit and fix the multifunctional vibrating actuator 1 to the bracket 3 in a given position relative to the surface of the circuit board 14. Therefore, even though the bracket 3 is floated by solder reflow fixing, it is always possible to assure contact between the contact points of the terminals 15, 16 and the electrodes 18', 19', so that the electrical connection between the multifunctional vibrating actuator 1 and the circuit board 14 will be certain.

[0068] Moreover, the multiple cut-outs 3c, 3c can be formed as a single unit by means of a cut 3f, such that the multiple cut-outs 3c are placed in the rim 3b in a single manufacturing process, thus simplifying the manufacturing process.

[0069] Sixth Embodiment

Next, the sixth embodiment of this invention for a structure for mounting on a circuit board is explained with reference to figures 18 and 19. Figure 18 is an oblique conceptual view of the multifunctional vibrating actuator involved in the sixth embodiment of the structure for mounting on a circuit board. Figure 19 is a plane view, from the bottom surface that faces the circuit board, of the bracket in which the multifunctional vibrating actuator of figure 18 is to be fitted and fixed. Now, the components that have the same functions as those in the embodiments described above also have the same labels in the drawings, and duplicative explanations are omitted or simplified.

[0070] The point on which the sixth embodiment differs from the embodiments described above is that the shape of the multifunctional vibrating actuator 20 as seen in plane view (in the direction of arrow a) has an unequal ratio of length to width, and the shape of the bracket 3 in which the housing 2 is fitted also has an unequal ratio of length to width in order to accommodate the multifunctional vibrating actuator 20. Hereafter, the shape as seen in plane view (in the direction of arrow a) is referred to, as necessary, as the plane view shape.

[0071] The plane view shape of the multifunctional vibrating actuator 20 and the bracket 3 is roughly rectangular, and the bottom face 3a' of the bracket 3 that contacts the circuit board 14 (not illustrated) has multiple contact points 3e, 3e located at the edges of the bracket 3 on its long axis.

[0072] By means of this structure, it is possible to have a greater space, relative to other embodiments, between the contact points 3e, 3e, so that a more definite self-alignment effect can be achieved. The bracket 3 can be fixed by solder reflow to the surface of the circuit board with even greater accuracy of positioning on the surface of the circuit board. Accordingly, the accuracy with which the multifunctional vibrating actuator 20, which is fitted and fixed in the bracket 3, can be attached to the surface of the circuit board is even greater than in other embodiments.

Brief Explanation of the Drawings

[0073] [Fig. 1] An oblique view showing an external view of the multifunctional vibrating actuator involved in the structure for mounting on a circuit board of the first embodiment.

[Fig. 2] A cross section, taken at the broken line A—A of figure 1.

[Fig. 3] An oblique view of the bracket that is a part of the multifunctional vibrating actuator.

[Fig. 4] An oblique view of the bracket in figures 1 through 3 when it is fixed by solder reflow to the surface of the circuit board.

[Fig. 5] A side view of figure 4.

[Fig. 6] A side view of the multifunctional vibrating actuator before it is placed in the bracket fixed to the circuit board.

[Fig. 7] A side view of the multifunctional vibrating actuator after it is placed in the bracket fixed to the circuit board.

[Fig. 8] An oblique conceptual view showing the relative positions of the multifunctional vibrating actuator and the circuit board within the portable terminal equipment.

[Fig. 9] An oblique view showing an external view of the multifunctional vibrating actuator of the second embodiment.

[Fig. 10] An oblique view showing the multifunctional vibrating actuator of figure 9 mounted on the circuit board.

[Fig. 11] A side view of the bracket.

[Fig. 12] A bottom plane view of the bracket in the third embodiment of the structure for mounting on a circuit board.

[Fig. 13] A plane view showing the bracket of figure 12 when fixed by solder reflow to the circuit board.

[Fig. 14] A bottom plane view of a modification of the bracket of figure 12.

[Fig. 15] A plane view showing the tops of the electrodes of the fourth embodiment of the structure for mounting on a circuit board.

[Fig. 16] A plane view of a modification of the electrodes in figure 15.

[Fig. 17] An oblique view of the bracket of the fifth embodiment and a portion of the housing of the multifunctional vibrating actuator to be fitted and fixed in the bracket.

[Fig. 18] An oblique conceptual view of the multifunctional vibrating actuator involved in the sixth embodiment of the structure for mounting on a circuit board.

[Fig. 19] A plane view, from the bottom surface that faces the circuit board, of the bracket in which the multifunctional vibrating actuator of figure 18 is to be fitted and fixed.

[Fig. 20] A side view showing the structure of a conventional multifunctional vibrating actuator.

[Fig. 21] An expanded oblique view of one terminal of the multifunctional vibrating actuator of figure 20.

[Fig. 22] An oblique view of a portion of the coil when connected to the terminal of figure 21.

[Fig. 23] A plane view of the circuit board for fixing the multifunctional vibrating actuator of figure 20 by solder reflow.

[Fig. 24] A plane view of the multifunctional vibrating actuator fixed to the surface of the circuit board of figure 23.

[Fig. 25] A section taken at broken [sic] line B—B of figure 24.

Explanation of key to drawings.

| | |
|------------------|------------------------------------|
| [0074] 1, 20 | Multifunctional vibrating actuator |
| 2 | Housing |
| 3 | Bracket |
| 4 | Diaphragm |
| 5 | Magnetic circuit |
| 6 | Magnet |
| 7 | Pole piece |
| 8 | Yoke |
| 9 | Terminal seat |
| 12 | Voice coil |
| 13 | Suspension |
| 14 | Circuit board |
| 15, 16 | Terminals |
| 17 | Solder |
| 18, 19, 18', 19' | Electrodes |
| 21 | Portable terminal equipment |